SPECIFICATION

COOLING DEVICE AND APPARATUS AND METHOD FOR MAKING THE SAME

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates generally to cooling devices, and more particularly to a cooling device for heat dissipation for electronic components, and to an apparatus and method for making the cooling device.

2. RELATED ART

[0002] Electronic apparatuses such as computers generate large amounts of heat. In a typical personal computer, this is due to electronic components such as semiconductors having high-density integrated circuits and employing high frequency operational clocks. There is much concern as to how to maintain an electronic component within an operating temperature range that ensures normal operation. High-density integration of circuits in Central Processing Units (CPUs) has dramatically increased in recent years, and clock frequencies of these CPUs have increased commensurately. Heat dissipation is highly important for stable operation and long operating lifetimes.

[0003] A cooling device is often attached directly on a CPU for maximum heat dissipation. A conventional cooling device comprises a base, a heat sink having a plurality of fins, and a heat pipe. The base is mounted on the surface of a CPU. The heat sink is attached to the base by welding or gluing. The heat pipe is arranged between the base and the heat sink. One end of the heat pipe is attached to the base by welding or gluing, and the other end of the heat pipe extends through

the fins of the heat sink and is attached therein by welding or gluing.

[0004] However, the base, heat sink and heat pipe of this cooling device are manufactured separately and then attached together. Three sets of molds are required for manufacturing the three individual components. Thus manufacturing costs of the cooling device are greatly inflated. In addition, the operation of welding or gluing the components together is unduly cumbersome and time consuming. Furthermore, cracks or seams may be formed during welding operations, and glues typically have low heat conductivity. These features can significantly reduce the heat dissipation efficiency of the cooling device.

SUMMARY OF THE INVENTION

[0005] Accordingly, an object of the present invention is to provide a cooling device which comprises a heat sink and a heat pipe integrally made.

[0006] Another object of the present invention is to provide an apparatus for making a cooling device having a heat sink and a heat pipe integrally made.

[0007] A further object of the present invention is to provide a method for making a cooling device having a heat sink and a heat pipe integrally made.

[0008] To achieve the above-mentioned objects, a cooling device for heat dissipation for a heat-generating component in accordance with a preferred embodiment of the present invention includes a heat sink and a heat pipe. The heat sink attached to the component includes a base and a plurality of fins extending from the base. The heat pipe is integrally formed with the heat sink. The heat pipe is filled with working liquid. A bottom portion of the heat pipe is formed between the base and the fins, the remainder of the heat pipe is formed through the fins. The base absorbs heat from the component. The bottom portion of the heat pipe absorbs heat from the base and transmits heat to the

remainder of the heat pipe by way of flow of the working liquid, whereupon heat is conducted to the fins.

[0009] An apparatus for making the cooling device in accordance with a preferred embodiment of the present invention includes a mold and a core accommodated in the mold. The mold includes a base part and a pair of symmetrical forming parts slidably engaged on the base part. The forming parts defines a plurality of slots, a cavity, and a recess respectively corresponding to the fins of the heat sink, the base of the heat sink, and the heat pipe.

[0010] A method for making the cooling device in the apparatus in accordance with a preferred embodiment of the present invention includes:

a) attaching the core to one of the forming parts;

b) closing the mold, with the two forming parts being slidingly attached together and abutting each other;

c) feeding molten material into the mold;

d) allowing the molten material to cool;

e) opening the mold, with the two forming parts being slidingly moved apart, and taking out a preform of the cooling device from the mold;

f) removing the core;

g) removing by-products formed as part of the preform;

h) sealing one end of the heat pipe being part of the preform;

i) filling working liquid into the heat pipe via the unsealed end thereof; and

sealing the unsealed end of the heat pipe.

[0011] Other objects, advantages and novel features of the present invention will be drawn from the following detailed description of preferred embodiments of the present invention with the attached drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is an isometric view of a cooling device in accordance with the preferred embodiment of the present invention;

[0013] FIG. 2 is an isometric view of an apparatus for making a cooling device in accordance with the preferred embodiment of the present invention;

[0014] FIG. 3 is an enlarged, isometric view of a core for use with the apparatus of FIG. 2;

[0015] FIG. 4 is similar to FIG. 2, but showing the core of FIG. 3 attached to the apparatus;

[0016] FIG. 5 is similar to FIG. 4, but showing the apparatus in a closed position; and

[0017] FIG. 6 is similar to FIG. 4, but showing the apparatus in an open position, and showing a cooling device preform formed with the core.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] Referring to FIG. 1, a cooling device 10 in accordance with the preferred embodiment of the present invention comprises a heat sink 14, and a heat pipe 13 integrally formed with the heat sink 14.

[0019] The heat sink 14 comprises a base 11. The base 11 is for attaching to a heat source such as an electronic component (not shown). A plurality of fins 12 extends upwardly from the base 11 for heat dissipation. The heat pipe 13 is

generally U-shaped, and is integrally formed through the base 11 and the fins 12 of the heat sink 14. A bottom portion of the heat pipe 13 is formed between the base 11 and the fins 12, and the remainder of the heat pipe 13 is formed transversely through the fins 12. Two sealed ends of the heat pipe 13 are exposed at one side of the heat sink 14. The heat pipe 13 is filled with capillary material and working liquid. When the base 11 absorbs heat from the electronic component, the bottom portion of the heat pipe 13 absorbs heat from the base 11, and transmits the heat to the remainder of the heat pipe 13 by way of flow of the working liquid, whereupon the heat is conducted to the fins 12.

[0020] The cooling device 10 is integrally formed with only a single mold 20 being required. This significantly reduces manufacturing costs. Moreover, the integrated configuration of the heat sink 14 and the heat pipe 13 helps ensure that the cooling device 10 operates dependably and efficiently. The integrated configuration of the cooling device 10 eliminates the drawbacks of conventional cooling devices such as cracks or seams formed during welding operations, or glues that typically have low heat conductivity.

[0021] Referring to FIGS. 2-4, an apparatus for making the cooling device 10 comprises the mold 20, and a core 30 accommodated in the mold 20.

[0022] Referring particularly to FIG. 2, the mold 20 comprises a base part 21, and a pair of forming parts 22 slidably engaged on the base part 21. Because the two forming parts 22 are symmetrically identical, only one of them will be described below. The base part 21 defines a pair of dovetail grooves 211 in a top face (not labeled) thereof. Each forming part 22 comprises a pair of bottom slide blocks 221 slidably engaged in the grooves 211. An inside of the forming part 22 defines a plurality of parallel slots 222, for forming the fins 12 of the cooling device 10. A cavity 224 is defined at a bottom of and in communication with the

slots 222, for forming the base 11 of the cooling device 10. A generally U-shaped recess 225 is defined in communication with the slots 222 and the cavity 224, for forming the heat pipe 13 of the cooling device 10. A bottom portion of the recess 225 is located where the cavity 224 adjoins the slots 222, and the remainder of the recess 225 is located transversely adjoining the slots 12. A chamber 226 is defined in the forming part 22 adjacent the slots 222, and in communication with ends of the recess 225. An elongated well 229 is defined above and in communication with the slots 222. The well 229 provides air venting when the mold 20 is filled with molten material, and also provides surplus molten material that is needed when molten material in the slots 222 solidifies and shrinks during the molding process. A sprue 228 is defined adjacent one end of the well 229, for feeding molten material into the mold 20. A conduit 227 is defined under and in communication with the sprue 228. A bottom end of the conduit 227 is in communication with the cavity 224. The conduit 227 conveys molten material from the sprue 228 to the cavity 224.

[0023] Referring particularly to FIGS. 3-4, the core 30 comprises a generally U-shaped main body 31, and a peripheral portion 32 integrally adjoining ends of the main body 31. The main body 31 and the peripheral portion 32 are respectively accommodated in the recess 225 and chamber 226, for forming the heat pipe 13 of the cooling device 10. The core 30 can be made of water-soluble material, sand, or metal pipe.

[0024] Referring to FIGS. 5-6, a preferred method for making the cooling device 10 comprises the following steps:

a) providing the mold 20, the two forming parts 22 being slidably mounted on opposite sides of the base part 21 by engagement of the slide blocks 221 of the forming parts 22 in the corresponding dovetail

grooves 211;

b) providing the core 30;

c) attaching the core 30 to one of the forming parts 22, the main body 31 and the peripheral portion 32 of the core 30 being respectively accommodated in the recess 225 and the chamber 226 of said one of the forming parts 22;

d) closing the mold 20, with the two forming parts 22 being slidingly attached together and abutting each other (see FIG. 5);

e) feeding molten material into the mold 20 via the sprue 228, the molten material passing through the conduit 227 and entering and filling up the cavity 224, the slots 222 and the recess 225;

f) allowing the molten material to cool;

g) opening the mold 20, with the two forming parts 22 being slidingly moved apart, and taking out a preform of the cooling device 10 from the mold 20 (see FIG. 6);

h) removing the core 30 as follows:

1) if the core 30 is made of water-soluble material, soaking the preform in water to dissolve the core 30, thereby providing the hollow heat pipe 13;

2) if the core 30 is made of sand, scouring the core 30 with high-pressure water to break the core 30 into pieces and wash the sand away, thereby providing the hollow heat pipe 13; or

3) if the core 30 is made of metal pipe, cutting the peripheral

portion 32 away from the preform, thereby providing the hollow heat pipe 13;

i) removing by-products 40, 50 formed as part of the preform (see FIG. 6);

j) sealing one end of the heat pipe 13 of the preform;

k) filling capillary material into the heat pipe 13 via the other unsealed end thereof;

l) filling working liquid into the heat pipe 13 via the unsealed end thereof; and

m) evacuating air from the heat pipe 13, and sealing the unsealed end thereof.

[0025] It is understood that the invention may be embodied in other forms without departing from the spirit thereof. Thus, the present examples and embodiments are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein. For example, the lower arm of the U-shaped heat pipe 13 may be fully embedded in the base 11 instead of halfly embedded disclosed in the present embodiment.